LAKE STATES ASPEN REPORT NO. 14

ASPEN FOR PULP AND PAPER

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FOREWORD

During and since World War II, there has been increasing interest in aspen (*Populus tremuloides*) in the Lake States, its availability and supply, properties and uses, and management. Aspen is a tree of primary importance in 20 million acres or 40 percent of the total forest area of the three Lake States - Michigan, Minnesota, and Wisconsin.

At an informal meeting at Madison, Wisconsin, in January, 1947, forestry representatives of several federal, state, and industrial groups in the Lake States agreed that it would be desirable to bring up to date what is known on aspen and make it available to anyone interested. The job of preparing this information in the form of reports was assigned to each of the groups listed below. The reports will be duplicated as rapidly as completed, and the entire project should be finished by the end of 1947. Each report will concern one aspect of the subject. Copies will be available from the Lake States Forest Experiment Station or from each contributor.

Report Number	Subject
1	Aspen Properties and Uses
2	Aspen Availability and Supply
3	Logging Methods and Peeling of Aspen
4	Milling of Aspen into Lumber
5	Seasoning of Aspen
6	Aspen Lumber Grades and Characteristics
7	Mechanical Properties of Aspen
8	Machining and Related Properties of Aspen
9	Aspen Lumber for Building Purposes
10	Aspen for Containers
11	Aspen for Core Stock
12	Small Dimension and Other Industrial Uses of Aspen
13	Aspen for Veneer
14	Aspen for Pulp and Paper
15	Aspen for Cabin Logs
16	Aspen for Excelsior
17	Aspen Defiberization and Refining of Product
18	Chemical Utilization of Aspen
19	Preservative Treatment of Aspen
20	Marketing of Aspen
21	Possibilities of Managing Aspen

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REPORT NO. 14

ASPEN FOR PULP AND PAPER

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INTRODUCTION

Although the use of hardwoods for pulp and paper manufacture has increased considerably during recent years in the Lake States, the pulpwood consumed in this region consists largely of softwood species of which about one quarter is obtained from foreign sources. The wood resource, on the other hand, is comprised to a large extent of hardwoods, predominantly aspen, with the maples, oaks, and several other species available in lesser amounts. The present stand of aspen in the Lake States is estimated at nearly 20 million acres with a total volume of merchantable timber of about 32 1/2 million cords. The present use of approximately 440 thousand cords of aspen as pulpwood is relatively small in comparison to the allowable annual drain of over 2 million cords (1, 2).2/ Though the use of softwood pulpwood in the Lake States will undoubtedly continue to be highly important, the potentialities of aspen as pulp and paper-making materials are such that its utilization for these purposes may readily be increased to a volume considerably greater than at present. Such an expanded use, however, would require not only an increase in production by present methods but the development of modified and new processes, modified paper formulas, some new products, and possibly the manufacture of some products not now manufactured extensively in the Lake States. Some of these will be discussed herein.

The statements in this report, though confined to methods applicable to quaking aspen (Populus tremuloides) and the paper products in which this species can be used, may be considered as also applying generally to other Populus species such as big-tooth aspen, eastern cottonwood, balsam poplar, balm-of-Gilead, and others which grow in the Lake States.

CHARACTERISTICS, PREPARATION, AND STORAGE OF ASPEN PULPWOOD

Aspen is a diffuse-porous hardwood of relatively light color and low density. The color of the heartwood varies from grayish white to light grayish brown. The sapwood is slightly lighter colored. The range of density of the aspen used for pulping is from about 20 to 24 pounds per

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1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Wisconsin, Madison, Wis.
2/ Underscored numbers in parentheses refer to literature cited.

cubic foot (oven-dry weight, green volume), which is low in comparison to many other hardwoods and some softwoods. This fact is important from the standpoint of the yield of pulp that may be obtained per cord of wood, especially as groundwood pulp. In chemical pulping, the relatively low weight of aspen wood per cord is compensated for by a relatively high cellulose content, so that the yield of chemical pulp that can be obtained per cord is nearly comparable to that of some of the softwoods.

The average fiber length of aspen is approximately 1 mm. and the average diameter about 0.03 mm., giving a ratio of length to diameter of 33 to 1. Pulps prepared from aspen also contain smaller fragments of woody tissue. This aggregate of relatively short fibers and cellular matter has a definite influence on the properties of the papers in which the pulp is used as a component. Aspen pulps are generally more suitable for use in papers requiring softness, bulk, opacity, good formation, and good printing qualities than in those requiring toughness, good strength, higher density, and harder surface characteristics.

A typical chemical analysis of aspen is given in table 1.

The pulpwood is usually cut to a 4-inch minimum top diameter in 100-inch lengths. Prior to the war, most aspen pulpwood was peeled in the woods. Wood cut in late summer and winter is more difficult to hand-peel. Winter-cut wood that remains green until spring will become growth active and hand-peel with less difficulty. However, it is necessary that practically all of the winter and spring-cut wood be peeled before the sap between the bark and wood has dried, that is, generally by the middle of July. The scarcity of woods labor during the war compelled most of the mills to accept unpeeled wood. With recent improvements in mechanical and hydraulic barking equipment, the continuation of the barking of hardwoods at some mills can be expected. On the other hand, there has been considerable interest shown recently in the development of a mechanized system of tree-length logging, skidding to a semi-portable mechanical barker, sawing to the desired length, and mechanically loading on trucks or trailers for hauling to mill or rail shipping points (3). Other developments in the mechanization of pulpwood logging in the Lake States are anticipated.

For the mechanical pulping processes, manufacturers prefer to purchase unpeeled aspen pulpwood in the green condition. In these mills the plan is to deliver the wood so that it can be used soon after it is received. When it is necessary to stock-pile aspen, it is stored for only a few months. The manufacturers of chemical pulp prefer to buy peeled wood, since seasoning is desirable for reducing trouble caused by gums and waxes. The average seasoning period for peeled aspen pulpwood is about eight months. If unpeeled aspen is purchased for use in the soda process, a seasoning period of at least one year is necessary. Peeled aspen can be stock-piled for as long as two years without serious losses in pulp yield. If unpeeled wood is stored in piles through a second summer, serious losses in pulp yield can be expected. For stock-piling unpeeled aspen, winter-cut wood is preferred to that cut in summer.

Table 1.--Density, fiber dimensions, and chemical composition of aspen (Populus tremuloides) (typical values)

Density (moisture-free weight and green volume)	lb. per cu. ft.	22
Fiber dimensions: Length	mm.	1
Diameter	mm.	0.03
Chemical composition: (based on moisture-free wood)		
Holocellulose: Total	percent	82
Cross and Bevan cellulose: Total	do.	64
Alpha cellulose: Determined on holocellulose	do.	51
Determined on Cross and Bevan	do.	48
Lignin	do.	17
Total pentosans	do.	23
Solubility in: Ether	do.	1
1 percent caustic soda	do.	19
Hot water	do.	3
Ash	do.	0.3

GROUNDWOOD PULPING

Aspen is suitable for the manufacture of both a coarse grade of groundwood pulp for use in insulating board and finer grades for use in groundwood book and specialty papers and newsprint. Recent experiments at the Forest Products Laboratory indicated that for the production of pulp of the quality used in book paper, duller stone surface conditions are preferable to sharper surfaces from the standpoint of production rate and energy consumption. For the production of pulps with equal properties, it is necessary to use conditions which consume much more energy per ton for grinding aspen than for grinding spruce. When ground under the same conditions, however, aspen pulp has higher freeness and lower strength than spruce pulp (4). Under the same conditions, aspen grinds at a higher rate, and consumes less energy per ton than spruce. The lower strength of the freer aspen groundwood pulp prepared with less energy consumption can be compensated by blending with strong aspen semichemical pulp. Experiments in which the pulp has been utilized in this way are described later. A comparison of aspen and spruce ground under the same conditions is given in table 2.

Table 2.--Comparison of aspen and white spruce groundwood pulps prepared under the same conditions 1/

		Aspen	Spruce
Grinding rate (moisture-free wood per 24 hours 2/	tons	0.96	0.64
Power input 2/	hp.	74	67
Energy consumed per ton moisture-free wood	hp.-days	77	104
Pulp suspension properties:			
Freeness (Canadian Standard)	cc.	113	20
Screen analysis:			
Retained on 24-mesh 3/	Percent	1.2	7.2
Retained between 24- and 80-mesh	do.	36.2	25.5
Retained between 80- and 150-mesh	do.	21.8	21.1
Passing 150-mesh	do.	40.8	46.2
Fiber length index	do.	.096	.089
Pulp test sheet properties: 4/			
Bursting	pts. per lb. per ream	.19	.45
Tearing	gm. per lb. per ream	.44	.72
Tensile	lb. per sq. in.	970	2680

1/ Carborundum pulp grinder stone. Grinding surface burred with a 10-cut, 1 1/2-inch lead spiral burr and a 14-point diamond burr. Surface condition, medium dull. Peripheral speed, 4,185 feet per minute. Pressure, 20 pounds per square inch of wood on stone. Grinder pit temperature, 165° F.: consistency, 3.5 percent.
2/ Per square foot of wood-stone contact area.
3/ Tyler standard mesh.
4/ Basis weight of test sheets, 115 pounds per ream (25 x 40 - 500).

SULFITE PULPING

Aspen is readily digested by the sulfite process. Because of the lower density, the weight of chips charged to a digester tends to be less than that of spruce chips. As mentioned above, however, the yield of pulp from the same weight of wood is higher, because of its higher cellulose content, so that the yield per digester charge or per cord is almost the same. The yield of aspen sulfite pulp can be expected to range normally between 46 and 54 percent by weight or between 720 and 1,170 pounds per standard rough cord. The time for penetration of cooking acid into the aspen chips at 110° C. is about the same as for spruce (5), but the cooking time is shorter because of faster pulping rate and lower initial lignin content (5). The cooking temperature may be reduced as much as 10° C. in comparison with spruce for the same cooking time.

Mixtures of aspen with spruce or balsam have been reported to cook satisfactorily in all proportions (6). Proportions of aspen varying from 10 to 30 percent are used in general practice, but the higher amount is said to give the best balance with regard to pulping time and pulp quality.

The bursting and tearing strengths of aspen sulfite pulp as indicated in table 3 are about 50 and 60 percent, respectively, of those of spruce sulfite pulp. Aspen sulfite pulp is soft and bulky, is easily bleached, and imparts good printing qualities to the book and magazine papers in which it is largely used. Other important uses of aspen sulfite pulp are in writing, mimeograph, toweling, and tissue papers. Small amounts have been used in newsprint. The proportion of aspen pulp used in these papers is variable, depending on the grades manufactured and the quality of the other pulps with which it is mixed.

SEMICHEMICAL PULPING

Tests at the Forest Products Laboratory have shown that aspen, because of its high cellulose and low lignin contents and light color, is especially suited to pulping by the neutral sulfite semichemical process. This process consists of partial chemical digestion of wood chips with a solution of sodium sulfite and sodium bicarbonate, followed by mechanical fiberizing of the softened chips. The yields of pulp obtained are high (70 to 85 percent) compared to those obtained by more complete chemical pulping processes, and the costs of production are low (7). The tearing strength of aspen unbleached neutral sulfite semichemical pulp is shown in table 3 to be higher, on a comparative basis, than aspen pulps prepared by the sulfite, soda, or sulfate processes and the same is indicated for the bursting strength except for that of the sulfate pulp.

Unbleached aspen semichemical pulp is used in the manufacture of insulating board and blanket. Corrugating board of excellent quality has been made experimentally at the Forest Products Laboratory from aspen semichemical pulp. Results of the Laboratory's work also indicate

possibilities of using unbleached aspen semichemical pulp to a considerable extent as a substitute for long-fibered coniferous pulps in liner board, specialty boards, and in combination with groundwood pulp in printing papers.

In spite of its high lignin content, experiments have shown that aspen neutral sulfite semichemical pulp is readily bleached by conventional chlorine processes (8) or with sodium peroxide (9) with yields of 58 to 80 percent (based on oven-dry wood) depending on the degree of bleaching. The bleached semichemical pulp is shown in table 3 to be higher than all the others in both strength properties. It will be observed that the strength of the bleached pulp is comparable to that of unbleached spruce sulfite pulp. Experimental runs at the Forest Products Laboratory followed by mill-scale trials indicated bleached semichemical pulp to be suitable for use in books, glassine, and tissues. In experiments on the making of machine-coated, groundwood-book paper, promising results were obtained by substituting aspen bleached neutral sulfite semichemical pulp for 60 percent of the softwood sulfite pulp used. The groundwood portion (50 percent of the total fiber furnish) consisted of a relatively free, moderate-energy-consumption, aspen pulp thus making a total of 80 percent aspen pulp in the furnish.

Aspen pulped by the acid sulfite semichemical process in the yield range of 55 to 65 percent was found in Forest Products Laboratory experiments to be a fairly satisfactory substitute for part of the spruce sulfite pulp in a creped towel paper.

SODA AND SULFATE PULPING

The largest use of aspen in paper making is in the form of soda pulp. For this purpose, it is digested either alone or in mixtures with other hardwoods. The yield of oven-dry, unbleached pulp obtained will vary within 45 to 50 percent by weight of oven-dry wood or from about 675 to 1,080 pounds per standard rough cord. Soda pulp is practically always bleached. The principal characteristics which this kind of pulp imparts to paper are opacity, bulk, softness, and absorbency. The strength of soda pulp is low in comparison with that of other kinds of pulp, the unbleached pulp varying from about 61 to 42 percent of the various strength properties of unbleached spruce sulfate pulp (5). Its principal use is in combination with bleached sulfite pulp in the manufacture of book paper. Some is used in tissues, particularly facial tissues.

A relatively small amount of aspen is pulped by the sulfate process. Unpeeled aspen can be pulped by this process with very little more chemical than is required for peeled aspen (10). It can be satisfactorily cooked in mixtures with jack pine in quantities up to 25 percent. This mixture has been noted to require approximately 10 percent less chemical than jack pine alone. The qualities reported (10) to be gained by using aspen with jack pine are better formation, a more closed sheet, and improved tearing strength. The mixture also requires less refining.

Coarse Fiber

Aspen is suitable for the production of a coarse fiber which is used largely by the roofing felt industry and in lesser amounts in the manufacture of insulating board, paperboard, and molded products. Wood marketed for this purpose is often called "fuzz wood," "fiber wood," or "felt wood" instead of pulpwood. The fiber can be made by the dry shredding of low-grade round wood, slabs, edgings, and other waste at least 2 feet in length. For best results it is said to be desirable that the wood be in a green or moist condition rather than dried out. Coarse fiber for similar purposes can also be made by the presteaming or by the mild chemical treatment of the wood, followed by fiberizing in attrition mills. This can be done continuously in single machines, or the treatment and milling can be done batchwise in separate equipment in a manner similar to the semichemical process described above.

Purified Pulp

Because of its high cellulose content and ease of pulping aspen is an attractive material for the production of purified pulp, also frequently called alpha pulp or "dissolving" pulp. This kind of pulp is used for the production of regenerated cellulose yarns and fabrics, lacquers, plastics, and explosives. Nearly all of the alpha pulp now produced is made from the longer-fibered softwoods. Only a small amount is produced from shorter-fibered hardwoods. It is probable that the increasing demand for alpha pulp will provide the incentive for a more extensive use of hardwoods. When techniques are developed which permit the more general use of shorter-fibered pulps, purified aspen pulp is likely to find ready acceptance. The wood could be digested by the sulfite process or a modified sulfate process and the pulp purified by conventional methods. The digesting of aspen with nitric acid has received considerable attention as a possible method of producing pulp for subsequent purification (11, 12). The possibility of obtaining a high yield of alpha pulp by the purification of neutral sulfite semichemical pulp is a factor favoring the consideration of that process.

Table 3.--Comparison of strength of aspen chemical and neutral sulfite semichemical pulps with that of spruce unbleached sulfite pulp 1/

Kind of aspen pulp	Bursting strength 2/	Tearing strength 2/
	Percent	Percent
Bleached semichemical	110	105
Unbleached semichemical	80	85
Bleached sulfate	80	90
Unbleached sulfate	90	75
Bleached soda	50	60
Unbleached soda	65	75
Unbleached sulfite	50	60

1/ From "Pulping Characteristics of Available Lake States and Northeastern Woods," by J. N. McGovern, E. R. Schafer, and J. S. Martin. TAPPI Monograph Series No. 4: 130-152 (1947). Forest Products Laboratory Report R1675 (1947).
2/ Relative to unbleached spruce sulfite pulp as 100 percent. Strength in the Schopper-Riegler freeness range of 550-600 cc.

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